Physics
Chapter 1

1- Current Intensity:

$I = \frac{Q}{t} = \frac{V}{R} = \frac{N.e}{t} = nAve$ where: $e = 1.6 \times 10^{-19}$ C, $N = \frac{Q}{e}$

2- Voltage (Electric Potential):

$V = \frac{W}{Q} = \frac{W}{N.e} = IR$

3- Resistance:

$R = \frac{V}{I} = \frac{\rho_e . l}{A} = \frac{\rho_e l^2 \rho}{m} = \frac{\rho_e m}{\rho A^2}$, $\rho_e = Resistivity$, $\rho = Density$

4- Conductivity & Resistivity:

$\rho_e = \frac{R.A}{l}$, $\sigma = \frac{l}{R.A}$, $\sigma = \frac{1}{\rho_e}$ $* \, l_{wire} = N \times 2\pi r_{coil}$

5- Ratio Between Two Resistors:

$\frac{R_1}{R_2} = \frac{\rho_{e1} . l_1 . A_2}{\rho_{e2} . l_2 . A_1} = \frac{\rho_{e1} . \rho_1 . l_1^2 . m_2}{\rho_{e2} . \rho_2 . l_2^2 . m_1} = \frac{\rho_{e1} m_1 \rho_2 A_2^2}{\rho_{e2} m_2 \rho_1 A_1^2}$, $\rho_e = Resistivity$, $\rho = Density$

6- Resistors Connection:

	Series	Parallel
I_t	$I_1 = I_2 = I_3 ....$	$I_1 + I_2 + I_3 + ...$
V_t	$V_1 + V_2 + V_3 .....$	$V_1 = V_2 = V_3 .....$
R_{eq}	$R_1 + R_2 + R_3 .....$	$\left(\frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} + \right)^{-1}$

At 2 parallel resistors: $\frac{R_1 . R_2}{R_1 + R_2}$

7- Ohm's Law for the closed-circuit:

- Ammeter Reading: $I = \frac{V_B}{R_{eq}+r}$
- $V_b = IR_{eq} + Ir$
- P.D across a discharging battery: $V = V_b - Ir$
- P.D across a charging battery: $V = V_b + Ir$

8- Efficiency of a battery:

$$Eff_{battery} = \frac{W_{out}}{W_{Battery}} = \frac{V_{out}}{V_B} = \frac{R}{R+r}$$

9- Current Divider (2 Parallel Resistors):

$$I_1 = \frac{R_2}{R_1+R_2} \times I_t \; , \; I_2 = \frac{R_1}{R_1+R_2} \times I_t$$

10- Voltage Divider (2 Series Resistors):

$$V_1 = \frac{R_1}{R_1+R_2} \times V_t \; , \; V_2 = \frac{R_2}{R_1+R_2} \times V_t$$

11- Electrical Potential Energy (work done):

$$W = V.Q = V.I.t = I^2.R.t = \frac{V^2.t}{R} = P_w\, t$$

12- Electric Power:

$$P_w = VI = I^2R = \frac{V^2}{R} = \frac{W}{t}$$

Same(I): $\frac{P_{w1}}{P_{w2}} = \frac{R_1}{R_2}$, Same(V): $\frac{P_{w1}}{P_{w2}} = \frac{R_2}{R_1}$

13- Power delivered and consumed:

$P_D = P_C$ Then:

- $P_D = V_B I$
- Charging battery: $P_C = V_B I$
- External resistance: $P_C = I^2 R$
- Internal resistance: $P_C = I^2 r$

Chapter 2

1- Magnetic Flux:

$\varphi_m - BA.sin\theta$

2- Magnetic flux density:

From Ampere's circular law($\int B\, d_l = \mu\, I$):

1. $B_{wire} = \frac{\mu I}{2\pi d} = 2 \times 10^{-7} \frac{I}{d}$ where $\mu_{air} = 4\pi \times 10^{-7}$

From Biot Savart law:

1. $B_{Circular\ loop} = \frac{\mu N I}{2r}$ where $N = \frac{l_{wire}}{2\pi r} = \frac{\theta}{360}$, $N \alpha \frac{1}{r}$

2. $B_{solenoid} = \frac{\mu N I}{l} = \mu\, n\, I$ where $n = \frac{N}{l}$

3- Magnetic flux density operations:

- Total magnetic flux:
  - Same direction: $B_T = B_1 + B_2$
  - Opposite direction: $B_T = B_1 - B_2$
  - Perpendicular to each other: $B_T = \sqrt{B_1^2 + B_2^2}$
- Reshaping (circular loop ⇔ solenoid): $\frac{B_{Circular\ loop}}{B_{solenoid}} = \frac{l_s}{2r_c}$
- At wire tangent to a circular coil: r=d, $NI_{circular\ coil} = \frac{I_{wire}}{\pi}$
- Solenoid turns are touching each other: $l = N \times 2r$

4- Force due to magnetic field:

$F = BIlsin\theta = \frac{I^2R}{v}$, Where v is the velocity of the wire

5- Mutual Force between 2 wires:

$F = \frac{\mu I_1 I_2 l}{2\pi d}$,   Where l is the length of the smaller wire

6- Suspending wire in the air:

$F = F_g \rightarrow BIl = mg = \rho V_{vol}\, g = \rho A l g$

Then: $BI = \rho Ag = \rho\pi r^2 g$ where: ρ = Density, g = gravity

7- Torque:

$\tau = BIAN\, sin\theta$

Sin θ	Cos θ
Coil & ⊥ Field	Coil & Field
⊥ Coil & Field	⊥ Coil & ⊥ Field

8- Magnetic dipole moment:

$|\overline{m_d}| = IAN = \frac{\tau}{Bsin\theta}$

9- Galvanometer:

Sensitivity $= \frac{\theta}{I}$

10- Conversion of Voltmeter to Ammeter:

$R_s = \frac{I_v R_v}{I - I_v}$

11- Conversion of Ammeter to Voltmeter:

$R_m = \frac{V - I_A R_A}{I_A}$

12- Ammeter:

- $R' = \frac{R_g R_s}{R_g + R_S}$
- $R_s = \frac{I_g R_g}{I - I_g} = \frac{V_g}{I_s}$
- $\frac{I_g}{I} = \frac{R_S}{R_g + R_S}$ = sensitivity
- $I = I_g(1 + \frac{R_g}{R_s})$
- At I =n I_g $\Rightarrow R_g = (n-1)R_s$

13- Voltmeter:

- $R' = R_g + R_m = \frac{V_m}{I_g}$
- $R_m = \frac{V - V_g}{I_g}$
- $\frac{V_g}{V} = \frac{R_g}{R_g + R_m}$
- $V = I_g(R_g + R_m)$
- At V =n V_g $\Rightarrow R_m = (n-1)R_g$

14- Ohmmeter:

- $R_{device} = R_{standart} + R_g + R_v + r$
- At $R_x = 0 \rightarrow I = \frac{V_B}{R_d}$
- At $R_x \neq 0 \rightarrow I = \frac{V_B}{R_d + R_x}$
- $\frac{I}{I_{max}} = \frac{R_{device}}{R_{device} + R_x}$
- $R_x = \frac{V_B}{I} - R_d$
- At I = $(\frac{1}{n}) I_{max} \Rightarrow R_x = (n-1)R_{device}$

Chapter 3

1- Electromagnetic Induction(faraday's law):

$$emf_{av} = -N\frac{\Delta\varphi}{\Delta t}$$

2- Induced Emf for a moving wire:

$$\text{Emf} = -Bvl\ \sin\theta$$

3- Special rule:

$$QR = -N \times \Delta B \times A$$

4- Mutual induction:

$$Emf_2 = -M \times \frac{\Delta I}{\Delta t}$$

Where: (M) is the coefficient of mutual induction, $N_2\Delta\varphi_2 = M.\Delta I$

- For solenoid: $M = \frac{\mu N_1 N_2 A_2}{l_1}$
- For Circular coil: $M = \frac{\mu N_1 N_2 A_2}{2r_1}$

5- Self Induction:

$$Emf = -L \times \frac{\Delta I}{\Delta t}$$

Where: (L) is the coefficient of self Induction, $N\Delta\varphi = L.\Delta I$

$$L = \frac{\mu A N^2}{l_{solenoid}} = \frac{\mu A N^2}{2r_{circular}} = \frac{Emf}{\frac{\Delta I}{\Delta t}},\ \frac{L_1}{L_2} = \frac{A_1 N_1^2 l_2}{A_2 N_2^2 l_1} = \frac{r_1^2 N_1^2 l_2}{r_2^2 N_2^2 l_1}$$

6- The rate of change in current intensity at a given moment(n):

$$V_B = V_R + V_i \rightarrow nV_R = V_B - L \times \frac{\Delta I}{\Delta t} \rightarrow nI = \frac{V_B - L \times \frac{\Delta I}{\Delta t}}{R}$$

7- Dynamo:

$Emf_{max} = NBA\omega = NBA.2\pi f$

$Emf_{inst} = Emf_{max}\, sin\theta = Emf_{max} sin(360ft)$

$I = I_{max} sin\theta$

Where: $f = \frac{1}{T} = \frac{n}{t}$, $\theta = 360ft$, $\omega = \frac{2\pi}{T} = 2\pi f = \frac{V}{r}$

Sin θ	Cos θ
Coil & ⊥ Field	Coil & Field
⊥ Coil & Field	⊥ Coil & ⊥ Field

$Emf_{avg(\frac{1}{2},\frac{1}{4})} = 4BANf$, $Emf_{avg(\frac{3}{4})} = \frac{4}{3}BANf$

$Emf_{eff} = \frac{Emf_{max}}{\sqrt{2}}$, $I_{eff} = \frac{I_{max}}{\sqrt{2}}$, $Emf_{av(\frac{1}{2},\frac{1}{4})} = \frac{2}{\pi}Emf_{max} = \frac{2\sqrt{2}}{\pi}emf_{eff}$

$\frac{N_{max}}{sec} = 2f$, $\frac{N_{zero}}{sec} = 2f + 1$

$P_w = Emf_{eff}.I_{eff} = I^2R = \frac{Emf_{eff}^2}{R}$

$W = P_w T = \frac{P_w}{f}$

8- Electric Transformer:

- General: $\eta \frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$
- Ideal: $\eta = \frac{V_p}{V_s} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$, $P_{wp} = P_{ws1} + P_{ws2} + \ldots$
- Non-Ideal: $\eta = \frac{V_s I_s}{V_p I_p} = \frac{V_s N_p}{V_p N_s}$, $\eta P_{wp} = P_{ws1} + P_{ws2} + \ldots$

$\eta = \frac{Energy_s}{Energy_p} \times 100 = \frac{Power_s}{Power_p} \times 100$

Where: η is the efficiency of the transformer

9- Transformer connected to a dynamo(Eff):

$$\eta \frac{N_s BA.2\pi f}{V_s.\sqrt{2}} = \frac{I_s}{I_p} = \frac{N_p}{N_s}$$

10- Electric Power Transmission:

$V_{Consumer} = V_{Station} - V_{wire}$ Where: V = IR

$P_{Consumer} = P_{Station} - P_{wire}$ Where: P = VI

Efficiency of transmission = $\frac{P_{Consumer}}{P_{station}}$

$R_{wires} = R_{1Km} \times Distance_{Km} \times Number\ of\ wires$

Chapter 4

1- Inductive reactance (X_L):

$X_L = \omega L = 2\pi f L$, $I_{max} = \frac{NBA}{L}$

Series	parallel
$x_L^{\backslash} = x_{L1} + x_{L2} + x_{L3} + ...$	$x_L^{\backslash} = \left(\frac{1}{x_{L1}} + \frac{1}{x_{L2}} + \frac{1}{x_{L3}} + ...\right)^{-1}$
$L^{\backslash} = L_1 + L_2 + L_3 + ...$	$L^{\backslash} = \left(\frac{1}{L_1} + \frac{1}{L_2} + \frac{1}{L_3} + ...\right)^{-1}$

2- Capacitance (C):

$C = \frac{Q}{V}$

3- Capacitive reactance(X_c):

$X_c = \frac{1}{\omega C} = \frac{1}{2\pi f C}$, $I_{max} = NBA\omega^2 C$

Series	parallel
$x_c^{\backslash} = x_{c1} + x_{c2} + x_{c3} + ...$	$x_C^{\backslash} = \left(\frac{1}{x_{C1}} + \frac{1}{x_{C2}} + \frac{1}{x_{C3}} + ...\right)^{-1}$
$C^{\backslash} = \left(\frac{1}{C_1} + \frac{1}{C_2} + \frac{1}{C_3} + ...\right)^{-1}$	$C^{\backslash} = C_1 + C_2 + C_3 + ...$

4- R-L circuit:

$V = \sqrt{V_R^2 + V_L^2}$, $Z = \sqrt{R^2 + X_L^2}$, $\tan\theta = \frac{V_L}{V_R} = \frac{X_L}{R}$

5- R-C circuit:

$V = \sqrt{V_R^2 + V_c^2}$, $Z = \sqrt{R^2 + X_c^2}$, $\tan\theta = \frac{-V_c}{V_R} = \frac{-X_c}{R}$

$$V = \sqrt{V_R^2 + (V_L - V_c)^2}\ ,\ Z = \sqrt{R^2 + (X_L - X_c)^2}\ ,$$

$$\tan\theta = \frac{V_L - V_c}{V_R} = \frac{X_L - X_c}{R}$$

7- Resonance:

- $F_\circ = \frac{1}{2\pi\sqrt{LC}}\ ,\ \omega = \frac{1}{\sqrt{LC}}$
- $\frac{F_1}{F_2} = \sqrt{\frac{L_2C_2}{L_1C_1}} = \sqrt{\frac{N_2^2A_2l_1C_2}{N_1^2A_1l_2C_1}}$
- $L = \frac{1}{4\pi^2F_\circ^2C} = \frac{\mu N^2A}{l} = \frac{X_L}{2\pi f}$
- $C = \frac{1}{4\pi^2F_\circ^2L} = \frac{Q}{V} = \frac{1}{2\pi f X_c}$

Chapter 5

1- Speed Of Light (C):

$c = \lambda \upsilon$ Where $\upsilon = \frac{no\ of\ vibrations}{time}$, $c = 3 \times 10^8$

2- Wien's Law:

$\frac{\lambda_{max\ 1}}{\lambda_{max\ 2}} = \frac{T_2}{T_1}$, $K^\circ = C^\circ + 273$

3- Energy of photon:

$E = h\upsilon_{light} = \frac{hc}{\lambda_{light}}$ Where $h = 6.625 \times 10^{-34}$

4- Kinetic energy of electron:

$K.E_{electron} = \frac{1}{2}m_e v^2 = eV$

Then:

- $V = \frac{m_e v^2}{2e}$
- $v = \sqrt{\frac{2K.E}{m_e}} = \sqrt{\frac{2eV}{m_e}}$

Where $m_e = 9.1 \times 10^{-31}$, $e = 1.6 \times 10^{-19}$, $v = velocity$, $V = P.D.$

5- Work Function of metal (E_w):

$E_w = h\upsilon_c = \frac{hc}{\lambda_c}$

6- Photoelectric Effect:

$K.E_{electron} = E_{photon} - E_w$

Then: $\frac{1}{2}m_e v^2 = h\upsilon_{light} - h\upsilon_c$, $eV = h\frac{c}{\lambda_{light}} - h\frac{c}{\lambda_c}$

7- Compton Effect:

$$\left(E_{photon} + K.E_{electron}\right)_{before\ collision} = \left(E_{photon} + K.E_{electron}\right)_{after\ collision}$$

8- Law of conservation of Energy:

$$E = mc^2 = h\upsilon = \frac{hc}{\lambda} = P_L c$$

9- Mass of photon:

$$m = \frac{E}{c^2} = \frac{h\upsilon}{c^2} = \frac{h}{c\lambda}$$

10- Momentum of photon(P_L):

$$P_L = mc = \frac{E}{c} = \frac{h\upsilon}{c} = \frac{h}{\lambda}$$

11- Power of photon(P_w):

$$P_w = \varphi_L E = \frac{E}{t} = \frac{h\upsilon}{t} = h\upsilon\varphi_L$$ Where $\varphi_L = \frac{N}{\Delta t} = \frac{F}{2P_L}$

12- Force of photon(F):

$$F = \frac{\Delta P_L}{\Delta t} = \frac{2mc}{t} = \frac{2h\upsilon}{c.t} = \frac{2h\upsilon\varphi_l}{c} = \frac{2h\varphi_l}{\lambda} = \frac{2P_w}{c}$$

Chapter 6

[Hydrogen Atom]

1- Radius of the orbit:

$$r_n = \frac{n\lambda}{2\pi} = \frac{nh}{2\pi m_e v}$$

2- Energy of a Level in a Hydrogen atom:

$$E_n = \frac{-13.6}{n^2}(eV)$$

3- Difference in energy between 2 energy levels(Photon Energy):

$$E_{photon} = \Delta E = E_{Higher} - E_{Lower}$$

Then(Hydrogen Atom):

1- Highest energy (shortest wavelength):

$$E_\infty - E_1 = \frac{hc}{\lambda} = h\upsilon \,, \qquad E_{photon} = -13.6 \times 1.6 \times 10^{-19}\left[\frac{1}{n^2_{lower}}\right]$$

2- Lowest energy (longest wavelength):

$$E_2 - E_1 = \frac{hc}{\lambda} = h\upsilon \,, \qquad E_{photon} = -13.6 \times 1.6 \times 10^{-19}\left[\frac{1}{n^2_{higher}} - \frac{1}{n^2_{lower}}\right]$$

4- Longest wavelength (Hydrogen atom):

$$\frac{1}{\lambda} = \frac{-13.6 \times 1.6 \times 10^{-19}}{hc}\left[\frac{1}{n^2_{higher}} - \frac{1}{n^2_{lower}}\right]$$

5- Number of spectral lines:

$$N = \frac{n^2 - n}{2}$$

6- In Coolidge tube:

1- Continuous spectrum (Soft radiation):

$$KE_e = eV = \frac{1}{2}m_e v^2 = E_{photon}$$

2- Line spectrum (Hard radiation):

$$E_{photon} = \Delta E = E_{Higher} - E_{Lower} \,, \qquad E_{photon} = h\upsilon_{x-ray} = \frac{hc}{\lambda_{x-ray}}$$

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Chapter 8

1- Law of mass action:

$n = p = n_i \quad \Rightarrow \quad np = n_i^2$

2- Semiconductors Rules:

	P-Type	N-Type
Electron concentration	$n \simeq N_D^+$	$n = \frac{n_i^2}{N_A^-}$
Holes concentration	$p = \frac{n_i^2}{N_D^+}$	$p \simeq N_A^-$
Return Pure	$N_A^- = N_D^+$	$N_D^+ = N_A^-$

3- Transistor As Amplifier:

- Emitter current (I_E)

$$I_E = I_B + I_C$$

- Collector current (I_C):

$$I_C = \alpha_e I_E$$

- Base Current (I_B):

$$I_B = (1 - \alpha_e) I_E$$

- Current Division (α_e):

$$\alpha_e = \frac{I_C}{I_E} = \frac{\beta_e}{1 + \beta_e}$$

- Current Gain (Amplification) (β_e):

$$\beta_e = \frac{I_C}{I_B} = \frac{\alpha_e}{1 - \alpha_e}$$

4- Transistor As Switch:

$V_{CC} = V_{CE} + I_C R_C$

Other

1- Percent error (approximation error):

$$\% = \left| \frac{Actual\ value - Expected\ value}{Expected\ value} \right| \times 100$$

2- Lorentz force(EKB chapter 2):

$F = Q(E + v \times B)$ where: E=external electric field, v=velocity

3- Coulomb's law (Electric force) & Newton's gravitational Law (EKB Chapter 1&6):

$F = K\frac{Q_1 Q_2}{d^2}$, $F_g = G\frac{m_1 m_2}{r^2}$

4- Electric field(EKB chapter 1):

$E = \frac{F}{Q} = K\frac{Q}{d^2}$

5- Electric Potential(EKB chapter 1):

$V = E \times d = K\frac{Q}{d} = \frac{1}{4\pi\epsilon_o}\frac{Q}{d}$, where K is a constant = $\frac{1}{4\pi\epsilon_o}$

Equivalent units by numbers :

Physical quantity	Unit	Number
Time (t)	sec.	0.1
Mass (m)	kg	1
Frequency (f) (ν)	hertz	10
Quantity of charges (Q)	coulomb	2
Current intensity (I)	ampere	20
Length (L)	meter	6
Momentum (P_L)	Kg.m/sec	60
Force (F)	newton	600
Self-inductance (L) Mutual-inductance (M)	henry	9
Resistance (R)	ohm	90
Capacitance (C)	farad	1/900
Magnetic Flux (ϕ)	weber	180
Potential difference (V) Induced emf (emf)	volt	1800
Planck's constant	Joule . sec	360
Energy (E) Work (W)	joule	3600
Torque (τ)	N.m	
Power (P)	watt	36000
Permeability (μ)	Tesla.m/Ampere	1.5
Magnetic flux density (B)	tesla	5
Resistivity (ρ_e)	Ω . m	540
Conductivity (σ)	$\Omega^{-1} . m^{-1}$	1/540
Dipole moment (m_d)	Amp. m^2	720

Examples:

$$\frac{sec}{\Omega} = \frac{0.1}{90} = \frac{1}{900} = \text{Farad}$$

$$\frac{\text{Joule}}{\text{Ampere} \ m^2} = \frac{3600}{20(6)^2} = 5 = \text{Tesla}$$

$$\frac{\Omega . sec}{m} = \frac{90(0.1)}{6} = 1.5 = \text{Permeability}$$

$$\frac{\text{Ampere}}{\text{volt} . m} = \frac{20}{1800(6)} = \frac{1}{540} = \text{conductivity}$$